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Whitney et al.

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[54] **METHOD OF MAKING WIRE ELEMENT CERAMIC CHIP FUSES**

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[73] Assignee: **Cooper Industries,** Houston, Tex.

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[51] **Int. Cl.**[6] **H01H 69/02**

[52] **U.S. Cl.** **29/623;** 29/411; 29/850; 264/61; 337/227; 337/297

[58] **Field of Search** 29/623, 411, 850; 264/61; 337/186, 187, 227, 228, 232, 297

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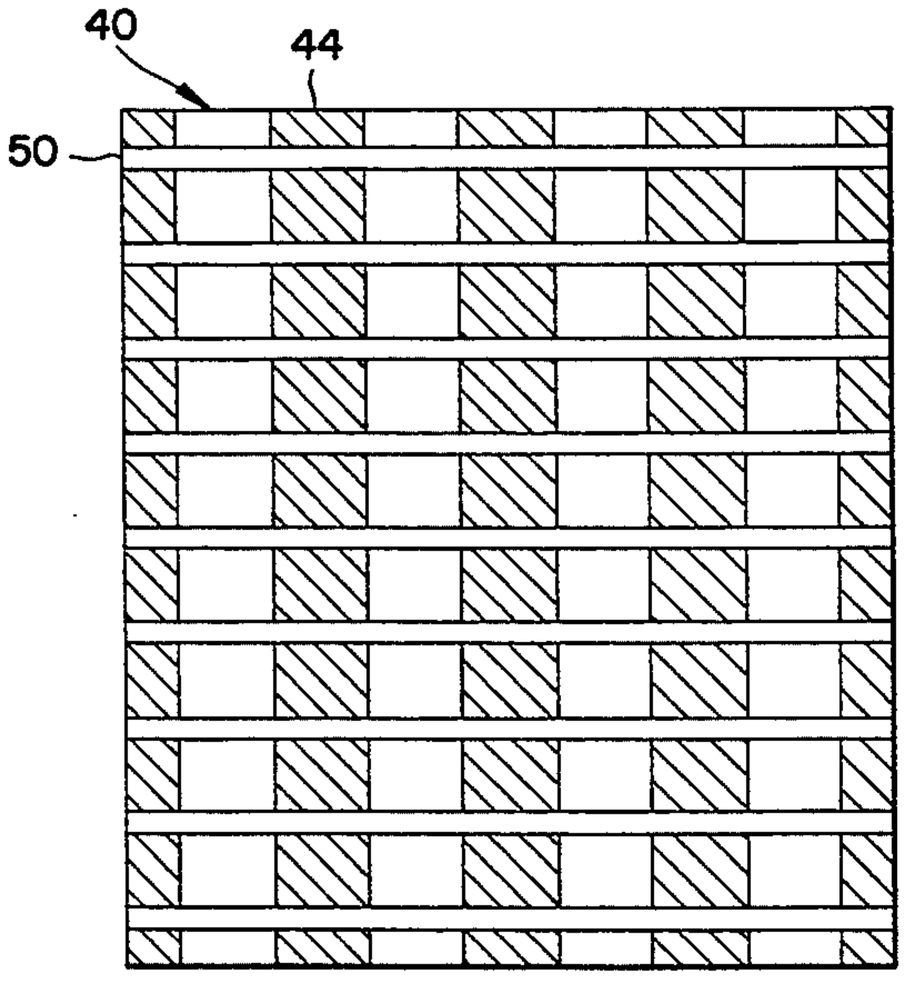
Primary Examiner—P. W. Echols

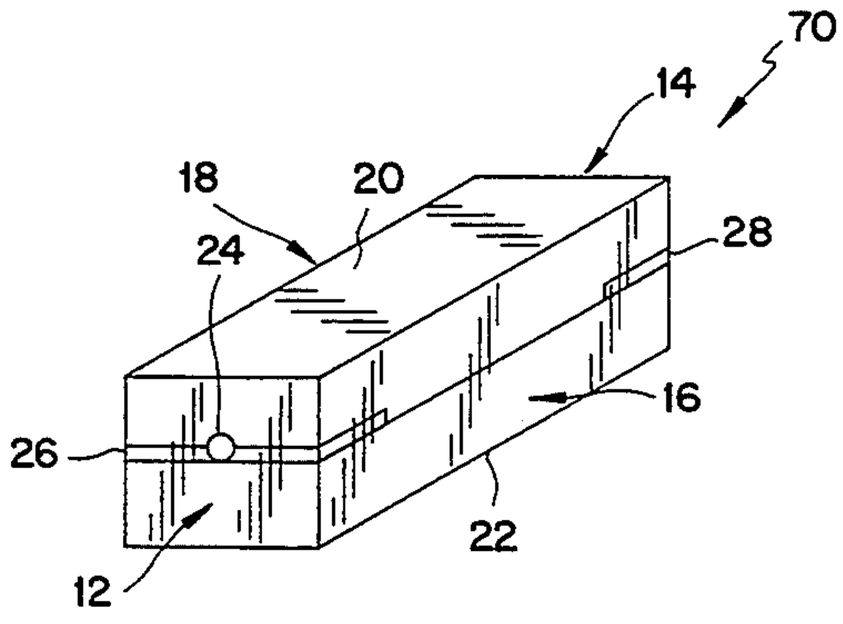
Attorney, Agent, or Firm—Burns, Doane, Swecker & Mathis

[57] **ABSTRACT**

A method of manufacturing a chip fuse includes the steps of depositing a plurality of columns of electrically conductive metal film on a green, unfired ceramic substrate, and disposing a plurality of wire elements on the substrate over the film columns and perpendicular to the film columns. A cover of green, unfired ceramic is bonded to the substrate over the wire elements and film columns to form a laminate. The laminate is then die cut into individual fuses, which are then fired to cure the ceramic and form an intermetallic bond between the wire elements and the metal film. End termination coatings are then applied to the fuses to facilitate connecting the fuses in an electrical circuit. The invention relates to a chip fuse manufactured according to the method.

12 Claims, 3 Drawing Sheets





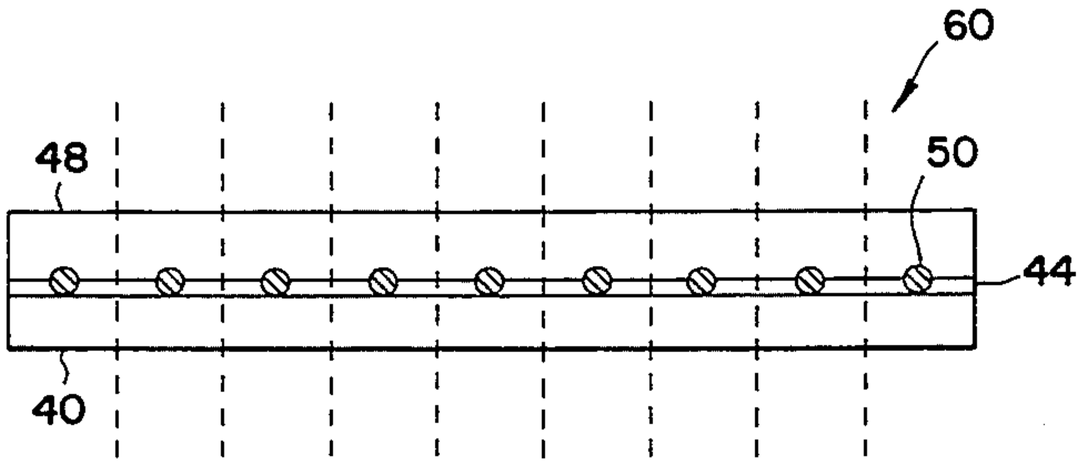


FIG. 1

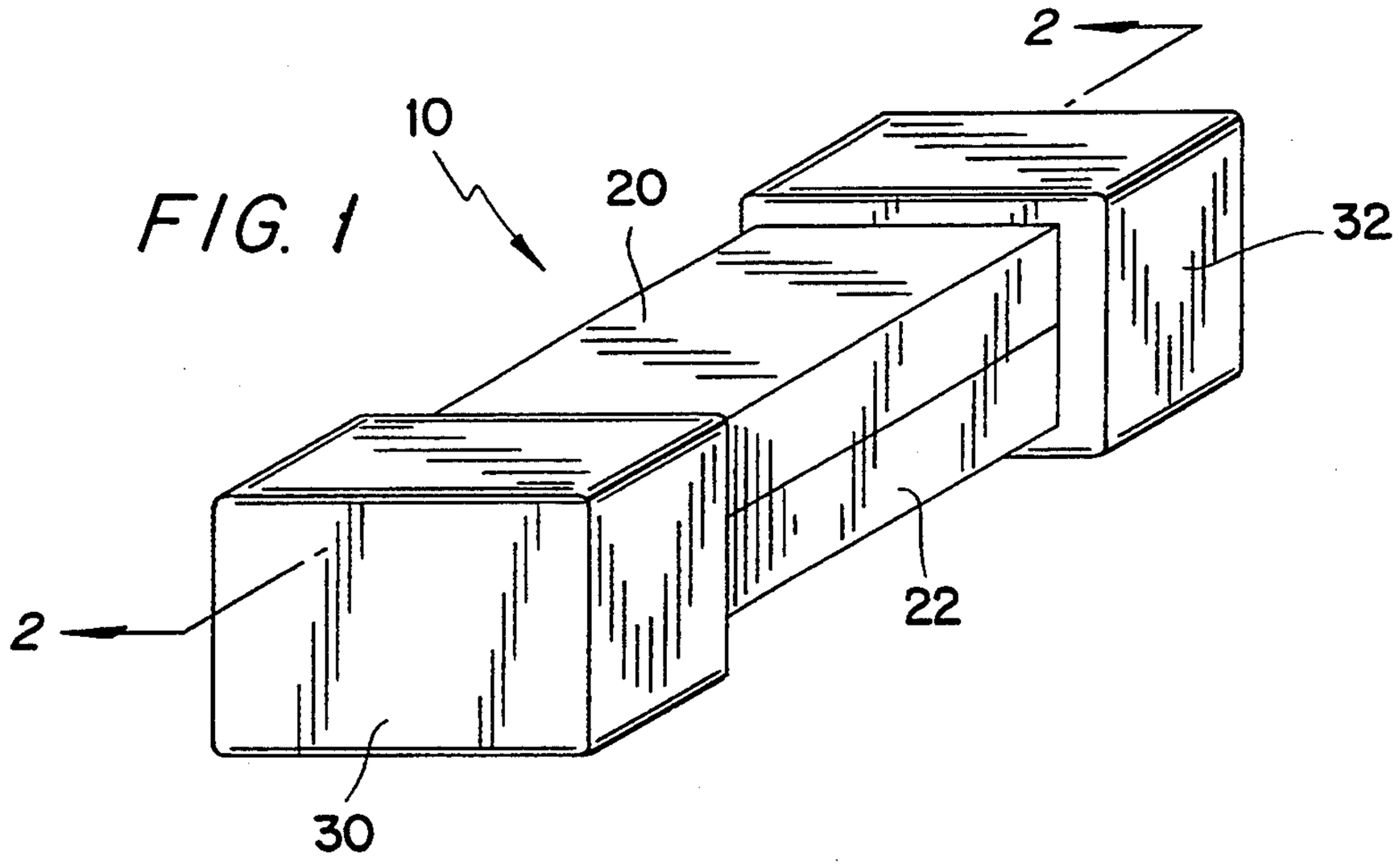
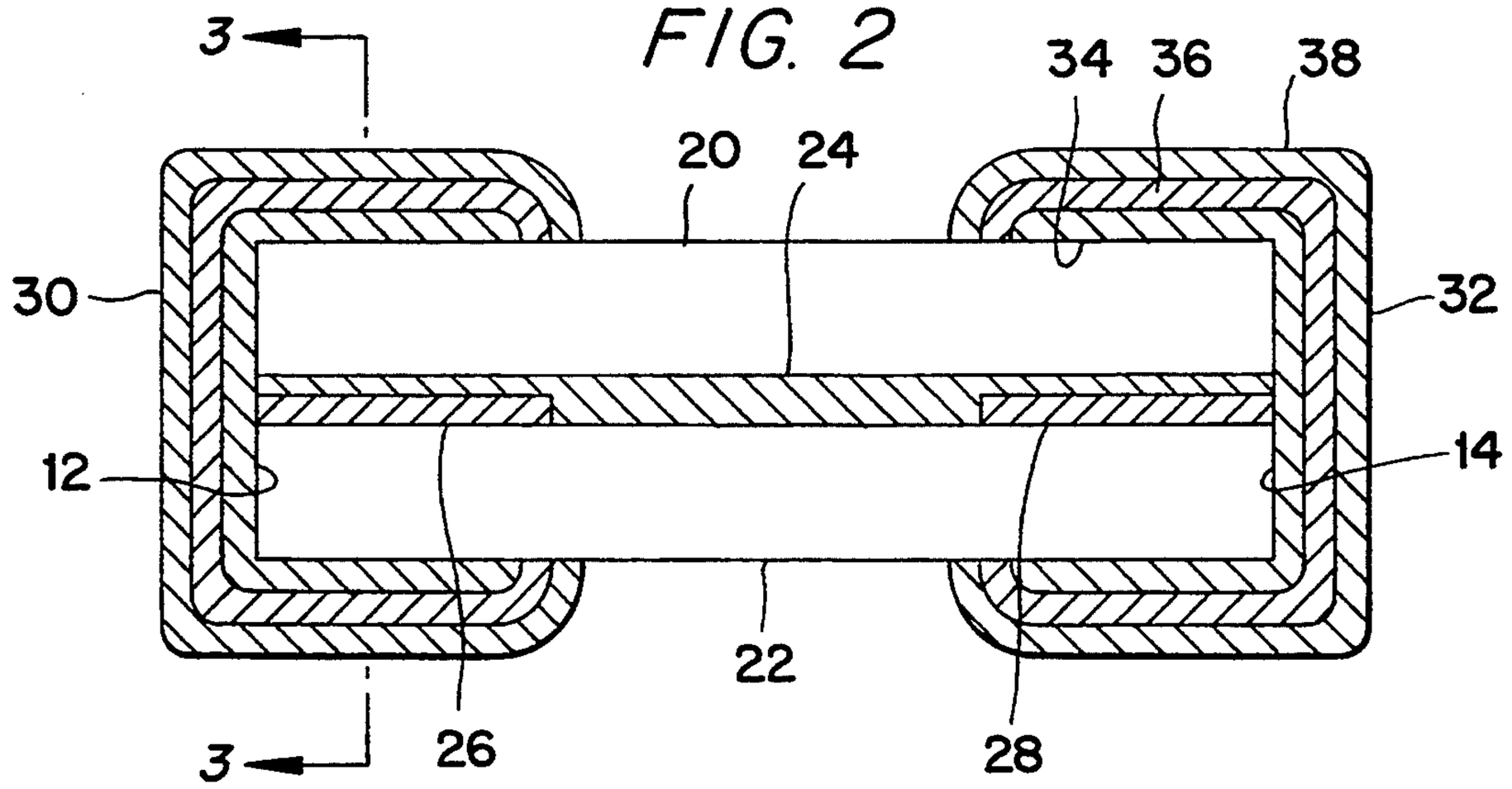


FIG. 2



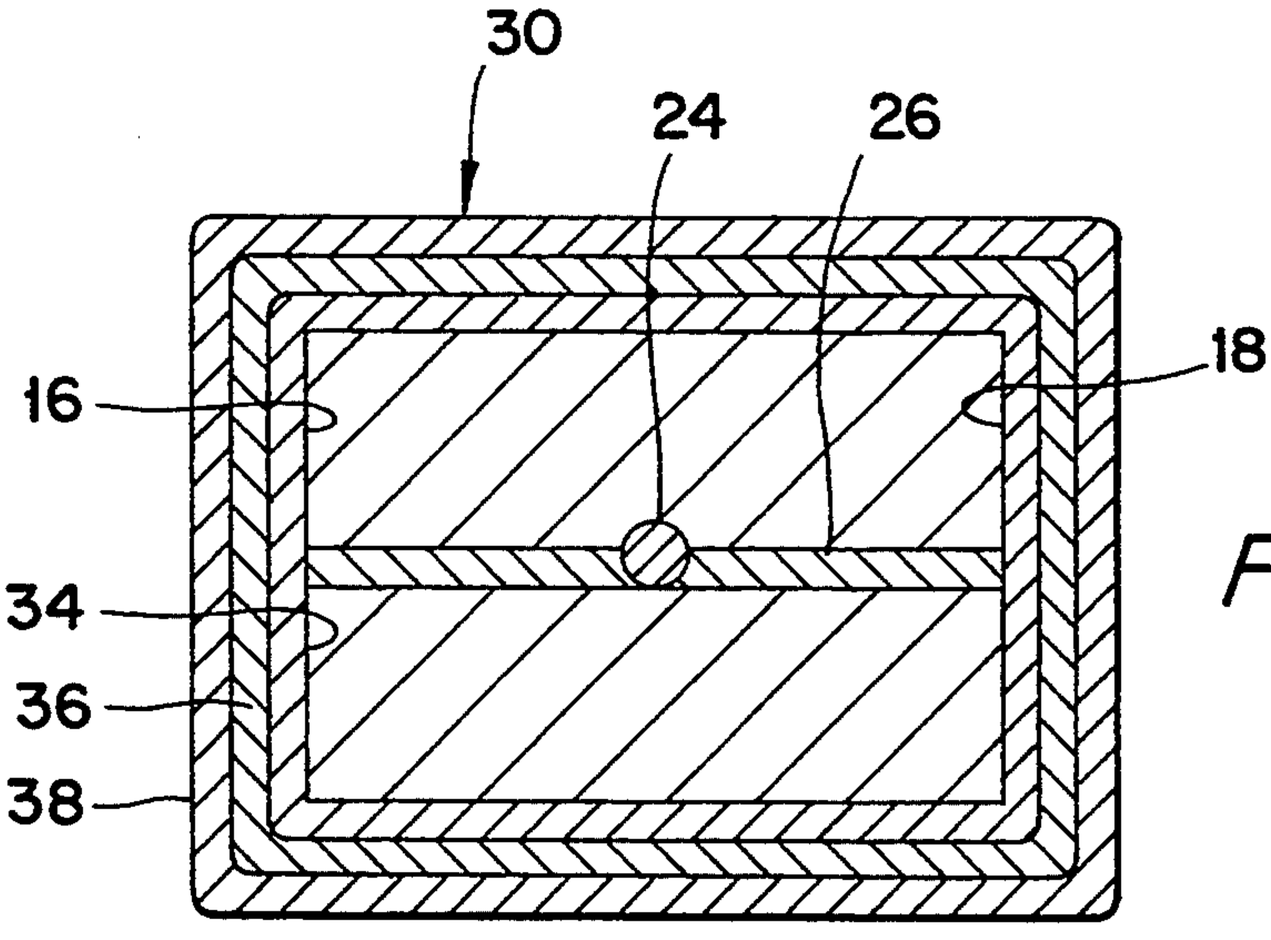


FIG. 3

FIG. 4

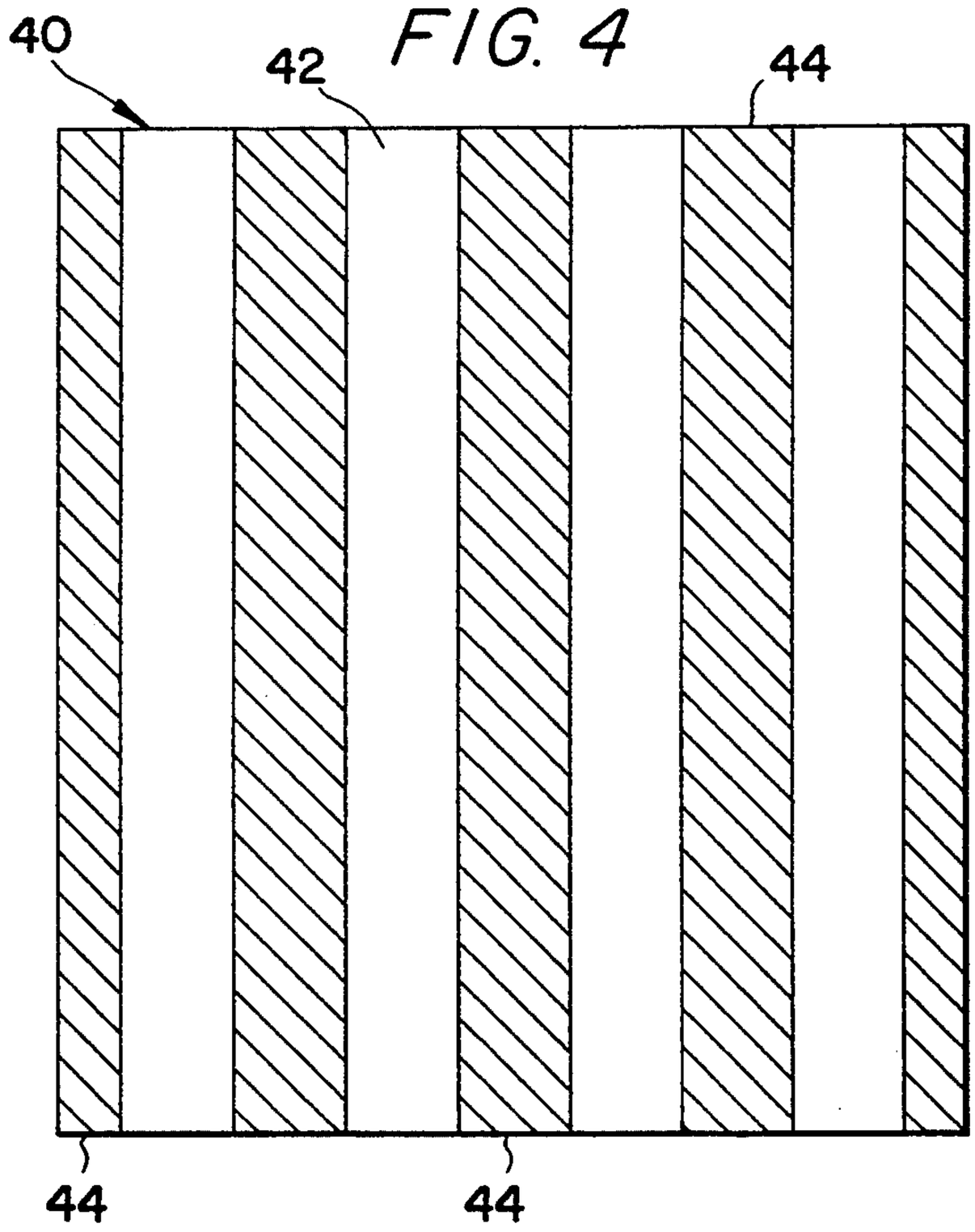


FIG. 5

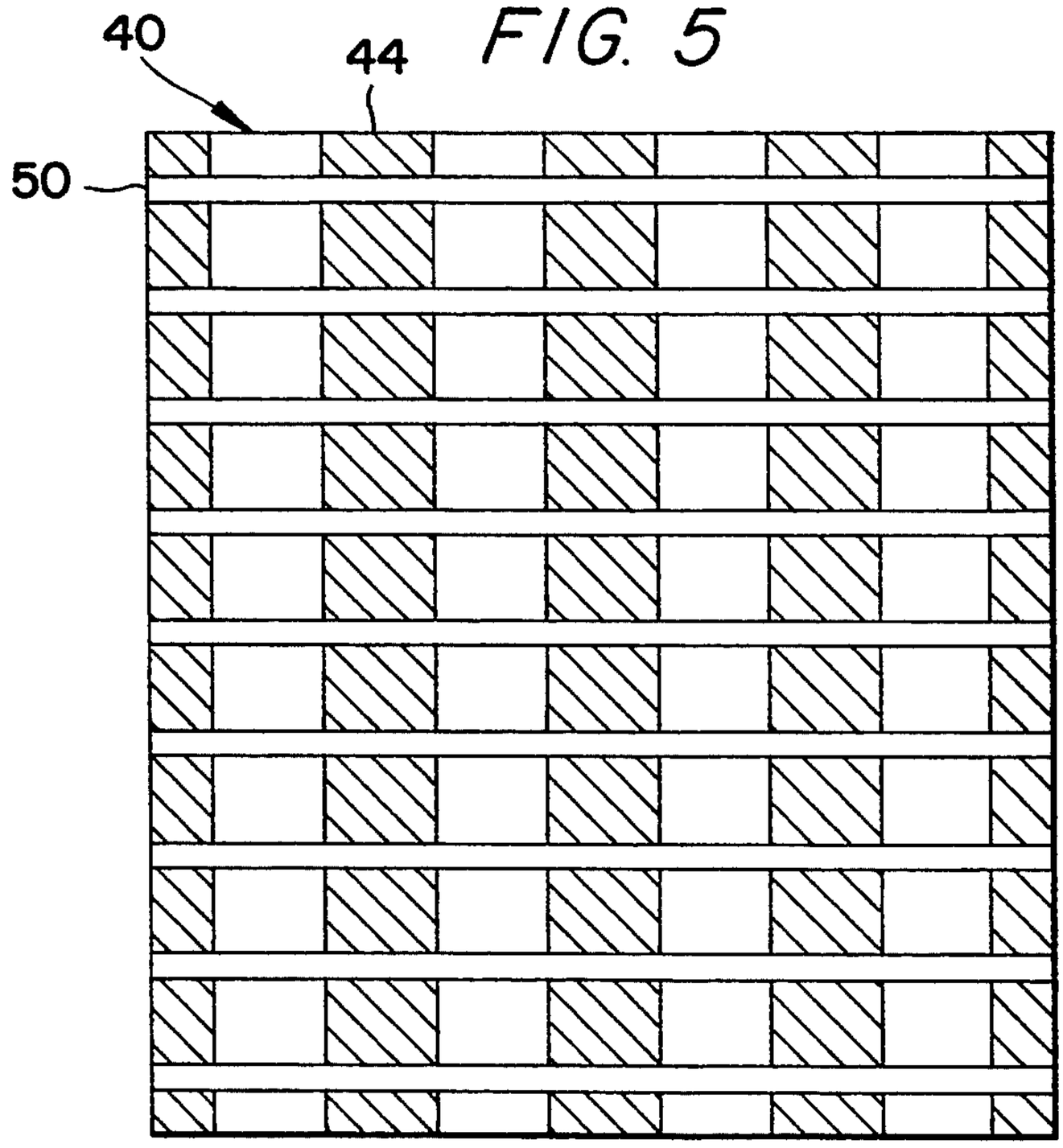


FIG. 6

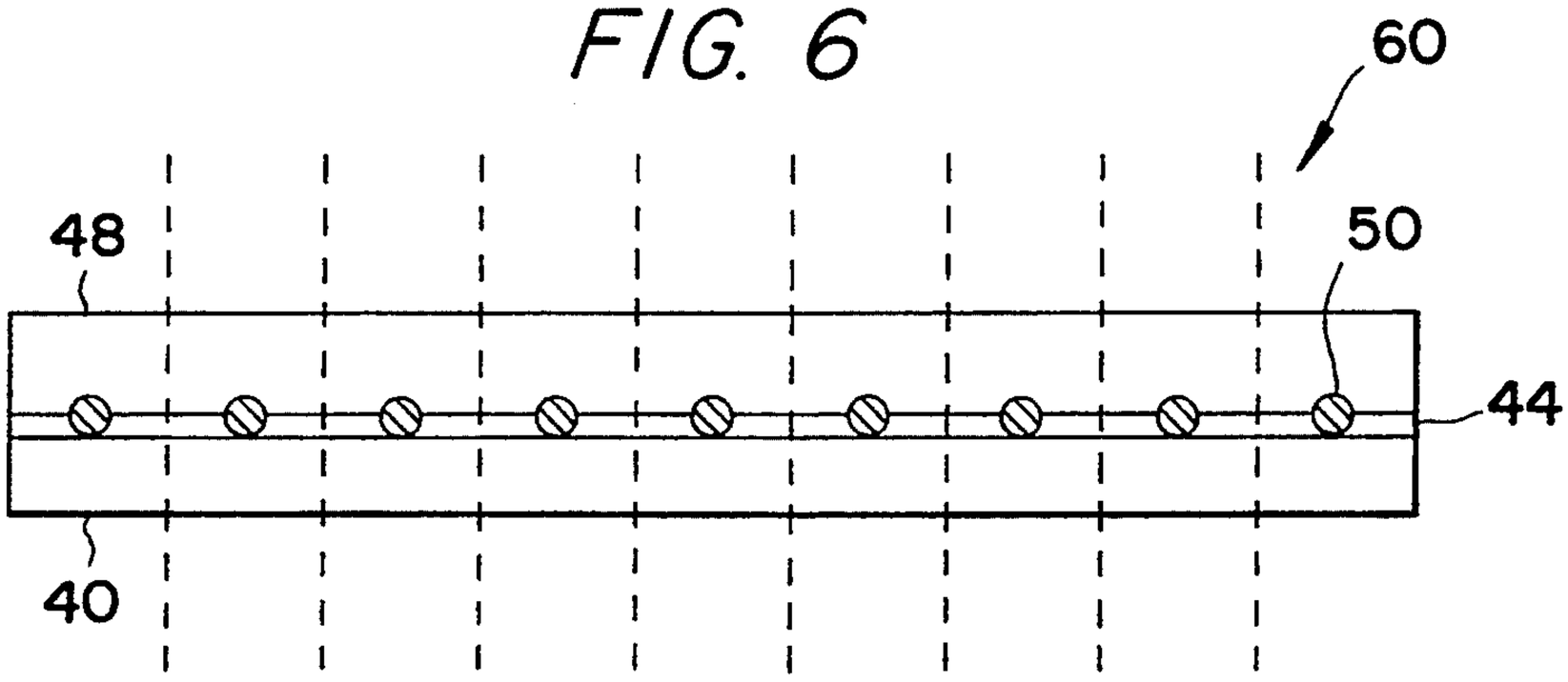


FIG. 7

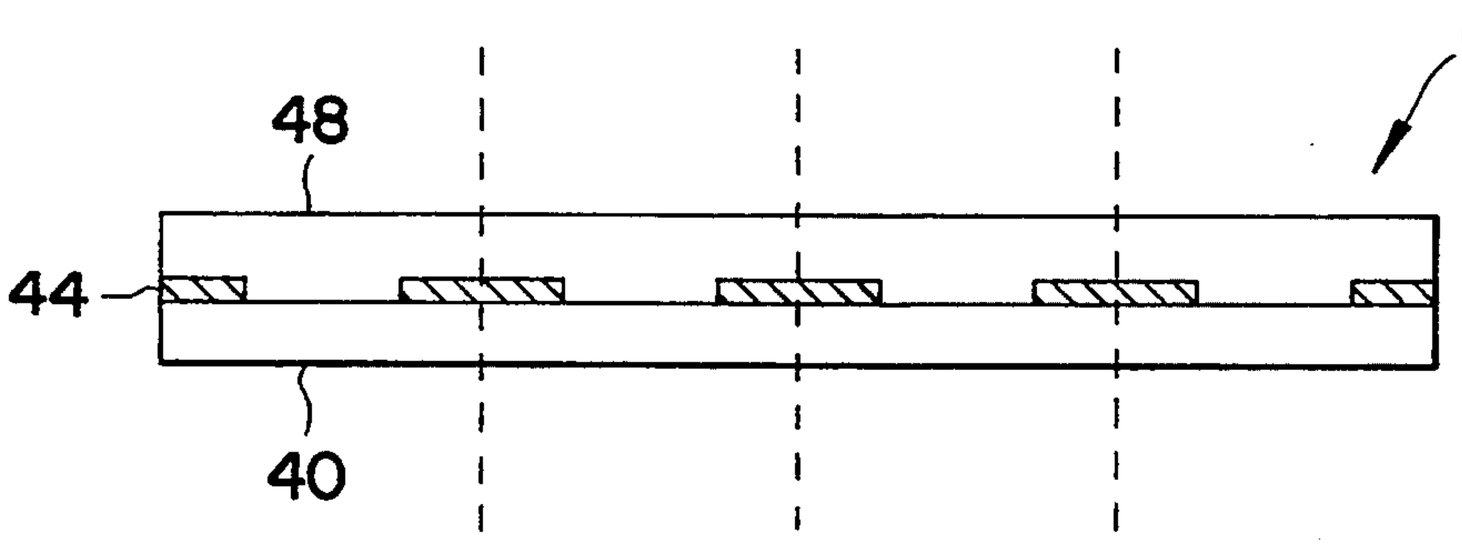
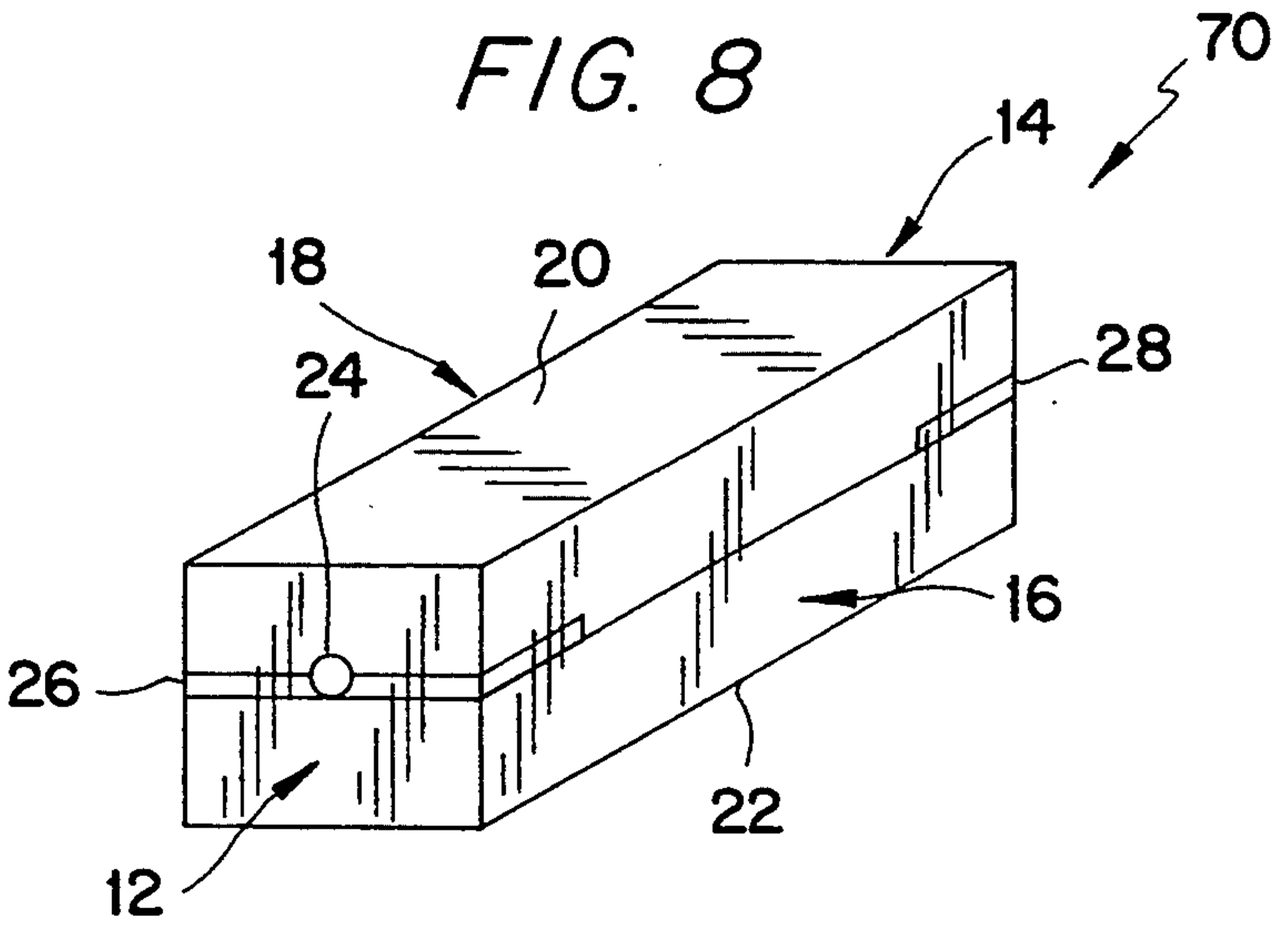


FIG. 8



METHOD OF MAKING WIRE ELEMENT CERAMIC CHIP FUSES

FIELD OF THE INVENTION

The present invention relates to a circuit protector. More particularly, the present invention relates to a method of manufacturing subminiature surface mounted circuit protectors having a wire fuse element. The invention also relates to a subminiature circuit protector having a wire fuse element.

BACKGROUND AND SUMMARY OF THE INVENTION

Subminiature circuit protectors are useful in applications in which size and space limitations are important, for example, on circuit boards for electronic equipment, for denser packing and miniaturization of electronic circuits.

Ceramic chip type fuses are typically manufactured by depositing layers of metal elements on a ceramic or glass substrate plate, attaching an insulating cover over the deposited layers, and cutting, or dicing, individual fuses from the finished structure. The Cutting operation is difficult and expensive to carry out. In addition, subminiature fuses made with deposited film fuse elements are generally limited to low voltage and current interrupting capacity.

The present invention, generally, provides a method of manufacturing a subminiature surface mountable circuit protector that is simple and relatively inexpensive. The present invention also provides a subminiature circuit protector that has improved short circuit current interrupting capacity compared to conventional circuit protectors of similar physical size.

More particularly, the present invention provides a method of manufacturing a multiplicity of subminiature circuit protectors from a plate of substrate material that facilitates the formation and rapid cutting of the substrate into individual units.

According to the present invention, a substrate plate of green, or unfired, ceramic material is prepared. Electrically conductive metallic film is deposited on a top surface of the substrate plate in equally spaced, parallel columns. Fuse elements, in the form of electrically conductive wires, are disposed on the top surface of the substrate perpendicular to the film columns, in equally spaced parallel rows. A second plate of green ceramic material is laminated to the substrate over the film columns and wire elements rows. The second plate covers and encapsulates the film columns and wire rows. The thus formed structure is then die cut, that is, cut, longitudinally through the metal film columns and transversely between the wire rows so that individual units are produced having strips of metal film at opposite ends and a wire element extending from end to end across a space between the metal film strips. The die cut individual units are fired to cure the ceramic substrate and cover plate and to cause an intermetallic bond to form between the wire elements and the metal film. The ends of the individual units are coated with electrically conductive materials to form electrical terminations for connecting in a circuit.

According to one aspect of the invention, the wire elements may be applied to the substrate by rolling and pressing the wire into the substrate. The application of pressure imbeds the wire elements in the substrate and helps form contact between the wire elements and the metallic film.

According to another aspect of the invention, the laminate structure is die cut so that the individual units formed have opposite ends faces and opposite lateral faces. A metal strip at each opposite end of each unit extends to the end face and to both lateral faces so that the electrical termination coatings applied to the units contact the metal strips on the end and lateral faces.

According to yet another aspect of the invention, the end termination coatings comprise a first coating of silver or a silver alloy. A second coating of nickel is applied over the first coating. A third coating of a tin/-lead alloy is applied over the nickel coating.

BRIEF DESCRIPTION OF THE DRAWING FIGURES

The present invention can be further understood with reference to the following description in conjunction with the appended drawings, wherein like elements are provided with the same reference numerals.

In the drawings:

FIG. **1** is a perspective view of a circuit protector manufactured according to the present invention;

FIG. **2** is a sectional view of the circuit protector of FIG. **1** taken along line **2—2**;

FIG. **3** is a sectional view of the circuit protector taken along line **3—3** of FIG. **2**;

FIG. **4** is a top view of a substrate plate illustrating a depositing step of the present invention;

FIG. **5** is a top view of the substrate plate of FIG. **4** after a subsequent step;

FIG. **6** is an end view of a laminate structure of the substrate plate of FIGS. **4** and **5** and a cover plate;

FIG. **7** is an end view of the laminate structure of FIG. **6** perpendicular to the view of FIG. **6**; and

FIG. **8** is a perspective view of an individual fuse unit produced from the laminate structure of FIGS. **6** and **7**.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

FIG. **1** is a perspective view of a subminiature circuit protector **10**, or fuse, manufactured according to the method of the present invention. The fuse **10** includes an upper plate **20** and a lower plate **22** laminated together. End terminations **30, 32**, at opposite ends of the fuse **10** electrically connect with the interior components of the fuse **10**, not illustrated in this figure. The end terminations **30, 32** also allow the fuse **10** to be connected in an electric circuit.

FIG. **2** is a sectional view of the fuse **10** of FIG. **1** taken along the line **2—2** of FIG. **1**. FIG. **3** is a sectional view taken along the line **3—3** of FIG. **2**. Between the upper plate **20** and the lower plate **22** of the fuse **10** is disposed a fuse element **24** that extends from one end face **12** to an opposite end face **14** of the fuse. The fuse element **24** is in the form of a wire. Strips of metal film **26, 28** are disposed at end portions of the fuse **10** in contact with opposite ends of the wire fuse element **24**. The metal strips **26, 28** each extend to one end face **12** (or **14**) of the fuse **10** and to both lateral faces **16, 18**. The metal strips **26, 28** contact the end terminations **30, 32** at the end faces **12, 14** and the lateral faces **16, 18** to form an electrical connection through the fuse **10**.

The end terminations **30, 32** are formed of three layers of electrically conductive material. A first, or inner layer **34**, comprises a coating of silver or a silver alloy. A second layer **36** comprises nickel and a third layer **38**

comprises a layer of tin/lead alloy that facilitates connecting the fuse **10** in an electrical circuit by soldering or other suitable means.

The wire fuse element **24** may be selected to have a desired diameter to provide a predetermined response to current and voltage.

FIGS. **4–7** illustrate a method of manufacturing the fuse **10** of the present invention. The method permits the manufacture of a multiplicity of individual fuses starting with a single substrate plate. FIG. **4** is a top view of a substrate ceramic plate **40** illustrating initial steps of the method. According to the present invention, a substrate plate **40** of green, or unfired, ceramic material having an upper surface **42** is first prepared. Electrically conductive metal film is deposited on the upper surface **42** as a plurality of parallel, spaced columns **44**. The metal film columns **44** may be applied by screen printing or another suitable method.

FIG. **5** is a top view of the substrate plate **40** of FIG. **4** illustrating a subsequent step of the method. After the metal film columns **44** are deposited on the upper surface **42**, a plurality of wire elements **50** are disposed on the upper surface **42** perpendicular to the metal film columns **44**, and in mutually spaced relationship. The wire elements **50** extend across and contact the metal film columns **44**. In a preferred embodiment of the method, the wire elements **50** are applied with a rolling applicator which moves across the substrate plate **40** and imbeds the wire element in the substrate as it travels. The wire elements **50** may also be applied by another suitable method.

The wire elements **50** may also be pressed into the upper surface **42** of the substrate plate **40**. Green ceramic material is relatively soft and pliable, and pressing the wire elements **50** imbeds the wire elements **50** in the substrate plate **40** to help secure it in place. Pressing the wire elements **50** also helps to make good contact between the wire elements **50** and the metal film **44**.

After the metal film columns **44** and the wire element rows **50** are in place on the upper surface **40** of the substrate, a second plate **48** of green ceramic material is laminated on the upper surface **42** of the lower plate **40**, as shown in FIG. **6** and FIG. **7**. FIGS. **6** and **7** are end views of the laminate structure **60**. The second plate **48** covers and encapsulates the wire elements **50** and the metal film columns **44**. As shown in FIGS. **6** and **7**, the wire elements **50** and the metal film columns **44** extend to end faces of the laminate structure.

The laminate structure **60** is then die cut to produce individual fuse units. FIG. **8** illustrates an individual unit **70** cut from the laminate structure **60**. A steel rule die, or other suitable tool, is used to cut the laminate structure **60** along the broken lines illustrated in FIGS. **6** and **7**. Each individual unit **70** produced has strips **26**, **28** of the metal film at opposite end portions and a wire element **24** extending from one end face **12** to an opposite end face **14**. As illustrated, the metal strips **26**, **28** also extend to the end faces **12**, **14** and to the opposite lateral faces **16**, **18** of the unit.

Die cutting the laminate structure **60** is facilitated by the unfired condition of the ceramic cover **48** and substrate **40**, which are relatively soft and easily cut in that state. The die cutting operation is thus performed with lower power required than in conventional methods. In addition, there is less loss due to breaking the ceramic during the cutting operation.

The die cut individual units are then fired as is known in the art to cure the ceramic material. During firing, the heat causes an intermetallic bond to form between the wire elements **50** and the metal film **44**, creating a reliable connection.

The individual units **70** are then coated with end terminations to form the fuse **10** of FIGS. **1–3**. According to a preferred embodiment of the invention, the individual units **70** are positioned by conventional vibratory sorting means in a fixture having a multiplicity of holes for holding the units. The units are held in parallel in the fixture, and the opposite end portions **12**, **14** at which the wire elements **50** terminate are dipped and coated with electrical conducting material in one or more steps.

The foregoing has described the preferred principles, embodiments and modes of operation of the present invention; however, the invention should not be construed as limited to the particular embodiments discussed. Instead, the above-described embodiments should be regarded as illustrative rather than restrictive, and it should be appreciated that variations, changes and equivalents may be made by others without departing from the scope of the present invention as defined by the following claims.

What is claimed:

1. A method for making chip fuses, comprising the steps of:

depositing a plurality of spaced, parallel columns of electrically conductive film on an upper surface of a green ceramic plate;

disposing a plurality of electrically conductive wire elements on the upper surface of the plate in mutually parallel spaced relationship and substantially perpendicular to the film columns;

bonding a cover plate of unfired ceramic material to the upper surface of the plate, the cover plate covering the film columns and wire elements to form a laminate structure;

dividing the laminate structure to form a plurality of individual fuses; and

firing the fuses to cure the ceramic and to create an intermetallic bond between the wire elements and the conductive metal film at mutual points of contact.

2. The method according to claim **1**, wherein the step of dividing the laminate structure into individual fuses is performed so that each fuse includes strips of metal film at opposed end portions and a wire element connecting the strips.

3. The method according to claim **2**, wherein the step of dividing the laminate structure is performed so that each fuse includes opposite end faces and opposite lateral faces and each strip of metal film extends to one end face and both lateral faces.

4. The method according to claim **1**, further comprising the step of applying at least one layer of an electrical termination coating to opposite end portions of the fuses after the firing step.

5. The method according to claim **4**, wherein the step of applying a termination coating is performed so that the layer contacts a portion of the metal film extending to an end face and opposite lateral faces of the fuse.

6. The method according to claim **4**, wherein a first coating step includes applying a layer of a silver alloy.

7. The method according to claim **4**, wherein a second coating step includes applying a layer of nickel over a first termination coating layer.

8. The method according to claim 4, wherein a third coating step includes applying a layer of a tin/lead alloy over a second termination coating layer.

9. The method according to claim 1, wherein the step of depositing the conductive metal film is by screen printing.

10. The method according to claim 1, wherein the step of disposing the wire elements is by rolling.

11. The method according to claim 1, further comprising the step of pressing the wire elements into the surface of the substrate.

12. The method according to claim 1, wherein the step of dividing the laminate structure is by cutting the laminate with a steel rule die.

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